

## ***Interactive comment on “Biases in regional carbon budgets from covariation of surface fluxes and weather in transport model inversions” by I. N. Williams et al.***

**Anonymous Referee #2**

Received and published: 11 September 2013

In "Biases in regional carbon budgets from covariation of surface fluxes and weather in transport model inversions", Williams et al., explore the effect that covariation between surface fluxes and atmospheric mixing. Previous work has focused on the diurnal or seasonal rectifier effects, while this work examines intermediate timescales with an aim toward documenting the frequencies at which inverse modeling frameworks are most susceptible to rectification. The authors do so by developing a stochastic boundary layer model (SBLM) which they use to generate synthetic timeseries for entrainment, fluxes, and boundary layer height. Inputs to the SBLM are derived from both observed and simulated (via CarbonTracker-TM5) CO<sub>2</sub> fluxes and concentrations at the South-

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ern Great Plains ARM site. This experimental design allows the authors to test whether the vertical rectifier in CT-TM5 behaves similarly to the real world.

The authors major conclusion is that, given that rectified vertical CO<sub>2</sub> gradients are largest at low frequencies, unless improvements are made in transport schemes, data should be assimilated at frequencies greater than 5 days to avoid biasing flux estimates. The corollary to this statement is that focusing on improving transport at lower, synoptic frequencies will provide the greatest improvement to our ability to estimate unbiased fluxes from CO<sub>2</sub> data assimilation.

Also of note is the authors' findings that interannual variability in vertical rectification is large, due to coupling of atmospheric vertical mixing and land surface properties. A particularly wet year in Oklahoma had large synoptic rectifier effects in comparison to a drought year. The wet year rectifier was larger for synthetic-CT-TM5 experiments than for synthetic-observation experiments, suggesting that the TM5 atmosphere is too highly coupled to the land surface.

These are significant findings that merit publication in ACP. Before publication, however, the paper would benefit from revisions that emphasize these results, which will be most useful in enabling the carbon cycle community to properly assess (and potentially improve) the errors and biases in inverse model-derived fluxes. As it reads now, the paper goes into great detail providing explanation of the SBLM, at the expense of discussion. With regards to the explanation of the SBLM, the first half of section 2 was quite clear while the second half didn't make any links back to the physical system. It is not until a later section that the authors give physical meaning to the quantities  $h$ ,  $F$ , and  $E$  introduced in the equations. I also felt that section 3.1 on input datasets would benefit from reorganization, since information on the datasets was unclear and presented in a somewhat random order.

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Interactive comment on Atmos. Chem. Phys. Discuss., 13, 19051, 2013.

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